Laboratory Standard Operating Procedures

SOP for the Evaluation of Rice Grain Appearance

FLAR Rice Quality Laboratory

This procedure was documented within the framework of FLAR's Quality Management System and adapted to the SOP format used in the CGIAR Breeding for Tomorrow Science Program.

The CGIAR Breeding for Tomorrow Science Program aims to maximize the return on investment of CGIAR and its partners in plant breeding, seed systems, and other initiatives by creating a collaboration hub to develop institutional standards for inclusive, impact-driven market segmentation and product profiling, and by developing a global platform for sharing market intelligence and guiding investment prioritization.

Acknowledgements: This work is part of the protocols registered in FLAR's Quality Management System. The CGIAR Breeding for Tomorrow Science Program falls under the Market Intelligence area, which is supported by the CGIAR Trust Fund contributors, whose support made the publication of this document possible. www.cgiar.org/funders

Laboratory Standard Operating Procedures

SOP for the Evaluation of Rice Grain Appearance

FLAR Rice Quality Laboratory

Katerine Loaiza de la Pava[1,2], Coordinator II

Érika Fernanda Giraldo Ossa[1,2], Research Assistant II

Andrea Fernanda Moná Cortés[1,2], Research Associate

Eduardo José Graterol Matute[1,2], Executive Director

[1] Latin American Fund for Irrigated Rice (FLAR)

[2] Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT)

May 2025

To be cited as:

Loaiza K; Giraldo EF; Moná AF; Graterol EJ. (2025). Laboratory Standard Operating Procedure SOP for the Evaluation of Rice Grain Appearance. Rice Quality Laboratory – FLAR. International Center for Tropical Agriculture (CIAT), Palmira, Colombia. 16 p.

Contents

1 Scope and Application

This standard operating procedure (SOP) outlines the evaluation of grain appearance in rice germplasm, with a focus on quantifying white core, measuring grain length and width, and calculating the length-to-width ratio. The procedure combines three complementary approaches: (i) visual assessment using a magnifying glass to identify white core; (ii) manual measurement of grain length with a vernier caliper as the reference method; and (iii) digital analysis of photographic images, enabling automated quantification of both white core and the physical dimensions of whole white rice grains. Additionally, quick start guides for the Vibe QM3i and MachVision Rice Analyzer equipment are provided, including descriptions of their main components and basic instructions for operation, handling, and data capture.

2 Principles and Definitions

White Core: A visual defect defined by opaque areas in the endosperm of rice grains, resulting from low starch particle compaction. This condition reduces grain appearance quality and increases susceptibility to breakage during milling. Although white core expression can be genetically controlled, it is strongly influenced by environmental conditions during grain filling and maturation.

Grain Length: The size of whole rice grains after milling.

MachVision Rice Analyzer: Equipment manufactured in Argentina that analyzes grain appearance through image capture, using an RGB multispectral system to statistically quantify white core and grain length.

Vibe QM3i: Device manufactured in Israel that analyzes grain appearance through image capture, using a high-resolution 10-megapixel industrial color camera to statistically quantify grain color and length, and relate these measurements to appearance defects.

Chalkiness: Visual defect marked by opaque areas on the rice grain endosperm surface, typically resulting from improper post-harvest handling or stressful conditions during grain formation, filling, or post-harvest. Unlike white core, chalkiness is not genetically determined, but develops under conditions such as high drying temperatures, sudden humidity changes, or storage in environments with high relative humidity, leading to internal cracks and alterations in starch structure.

3 Equipment

- Magnifying glass
- Fine tweezers for grain handling
- Opaque surface in black, green, or blue
- Vernier caliper
- Soft cloth or brush
- MachVision Rice Analyzer
- Vibe QM3i Image Analyzer
- Computer with software to operate and process data from the MachVision and Vibe QM3i analyzers

3.1. Vibe QM3i Image Analyzer

The Vibe QM3i is a high-precision image analyzer designed to evaluate grain physical characteristics, including length and the presence of white core. The equipment combines an internal optical system with specialized software to enable automated image capture and analysis, producing quantitative data with high reproducibility. Key components of the Vibe QM3i include a work plate to place the grains, a motorized gate that regulates sample entry, and a high-resolution camera housed within the device. The analyzer is operated from a computer using the system's software, which processes the images and generates the measured parameters.

Here is a description of the Vibe QM3i Image Analyzer components (Figures 1, 2, and 3):

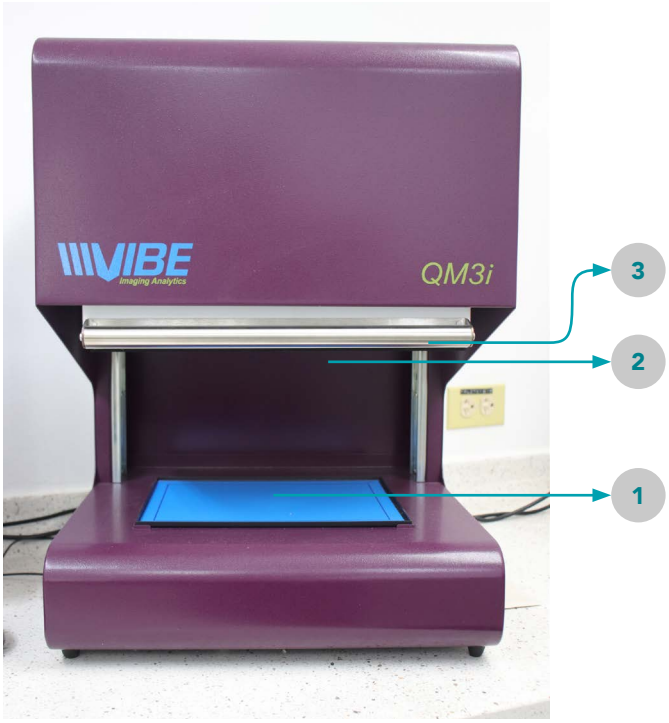

Figure 1. Front view of the Vibe QM3i

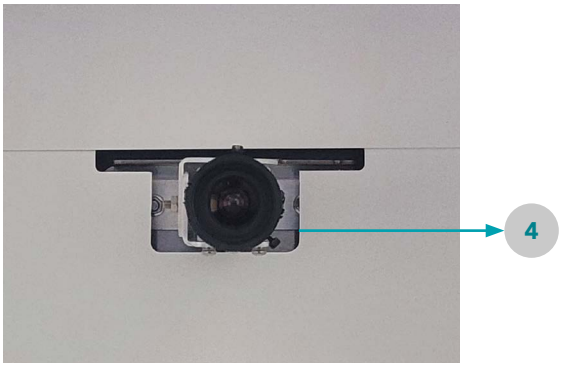

Figure 2. Interior of the Vibe QM3i

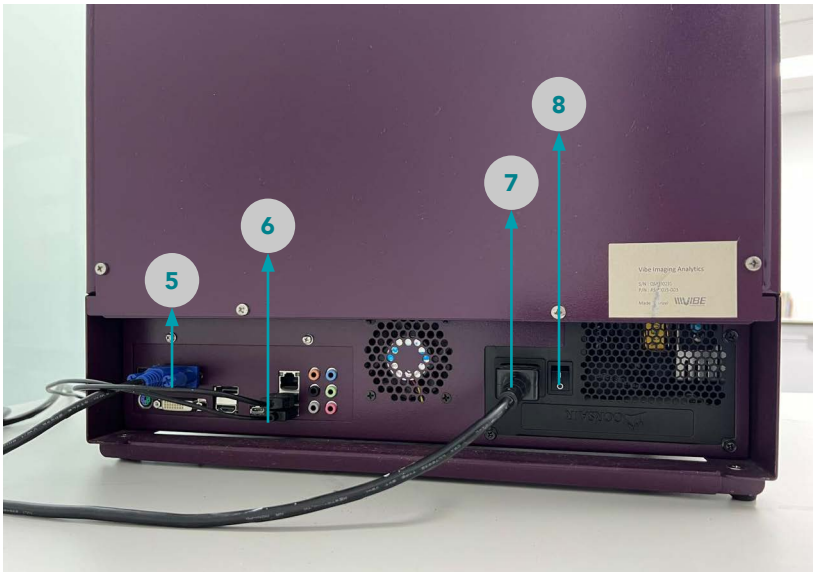

Figure 3. Rear view of the Vibe QM3i

1. Work plate
2. Vibe QM3i sample gate
3. Gate piston
4. Vibe QM3i internal camera
5. VGA cable
6. USB plugs
7. Power cable
8. ON/OFF switch

3.2. MachVision Analyzer

The MachVision Rice Analyzer is an automated device for the physical evaluation of polished rice grains. It measures parameters such as length, width, and area, and detects physical defects or alterations, including white core, spots, and breaks, using multispectral imaging. Samples are placed in the input hopper and transported by a conveyor belt, while cameras capture images of each grain in motion. The device's software automatically processes the images, producing a detailed report of the analyzed physical attributes.

Here is a description of the MachVision Rice Analyzer components (Figure 4):

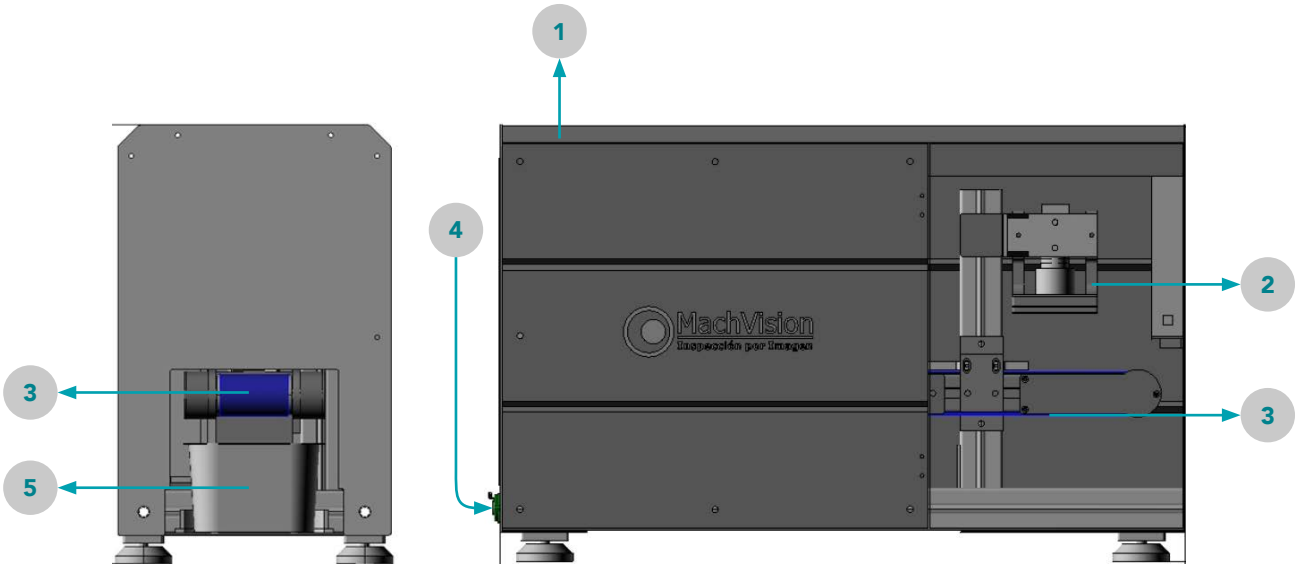

Figure 4. Front and rear view of the MachVision analyzer

1. Product input hopper
2. Camera system
3. Conveyor belt
4. ON/OFF switch
5. Product output hopper

4 Procedure

4.1. Procedure for Visual Evaluation of White Core

1. Weigh 5 g of polished rice grains (250 grains).
2. Place the grains on a black, green, or blue surface to enhance contrast.
3. Sort the grains according to the visual scale (Figure 5). Examine them using a magnifying glass.

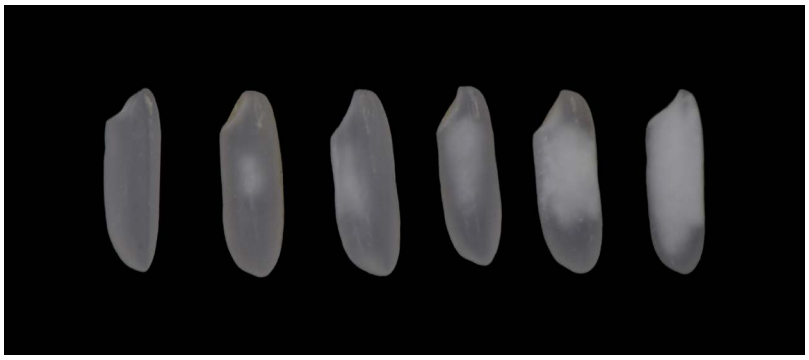

Figure 5. White Core Evaluation Scale

4. Make sure the groups do not contain the same number of grains.
5. Combine the groups with the fewest grains, prioritizing combinations of groups with consecutive values on the classification scale, so that only five groups remain. Aim for each group to contain approximately 50 grains.
6. Record the classification of each group, then calculate the average white core value for the entire sample. Figure 6 provides an example of how this average is determined and calculated:

Classification	0	1	2	3	4	5	$\bar{x}$
Sample ID	3	0	1	1	0	0	

Figure 6. Group Classification of White Core in the Sample

This indicates that there are three groups: one classified as 0 (no white core), one as 2, and one as 3.

To calculate the average white core value, multiply each classification value by the number of groups in that category (see Figure 7). Sum the results, then divide the total by five, which is the total number of groups, as follows:

Classification	0	1	2	3	4	5	$\bar{x}$
Sample ID	3	0	1	1	0	0	
	0 + 0 + 2 + 3 + 0 + 0						
	5						5/5 = 1,0

Figure 7. Average White Core in the Sample

In this case, a value of 1.0 represents the numerical average of white core in the sample. FLAR's breeding program selects materials with values ≤ 0.8, while values ≥ 1.0 are generally considered undesirable by both the milling industry and consumers in Latin America and the Caribbean. Exceptions exist, however, in which grain with a high white core rating may command a premium price on the market.

4.2. Procedure for Determining Grain Length with a Vernier Caliper

1. Select 20 grains randomly from a sample of polished, whole grains.
2. Measure the distance between the two longitudinal ends of each grain using the caliper and record the values in millimeters.
3. Calculate the average grain length from the measurements obtained.
4. Classify the grains according to Figure 8, following the IRRI (1966) guidelines, based on the average value obtained.

Length (mm)	Classification	
≤ 5.5	Short	
5.51 to 6.6	Medium	
6.61 to 7.5	Long	
> 7.5	Extra Long	

Figure 8. Grain length classification.

4.3. Procedure for Determining the Length-to-Width Ratio Using a Vernier Caliper

1. Select 20 grains randomly from a sample of polished, whole grains.
2. Measure the length and width of each grain in millimeters using a caliper, taking the width at the widest part of the grain cross-section.
3. Calculate the average length and average width from the 20 grains, then determine the length-to-width ratio (L/W) by dividing the average length by the average width.
4. Classify the grains based on the ratio shown in Figure 9. IRRI (1966) defines ratios above 3.0 as slender grains and those below 3.0 as round grains.

Classification	Grain Shape	
≤ 1,1	Round	
1,1 a 2,0	Broad	
2,1 a 3,0	Medium	
> 3,0	Slender	

Figure 9. Classification of Grain Length-to-Width (L/W) Ratio.

4.4. General Procedure for Operating the Vibe QM3i Image Analyzer

The following provides a general overview of the steps for capturing, processing, and quantifying rice grain images using the Vibe QM3i analyzer.

4.4.1 Image Preparation and Capture

1. Connect the equipment to a 120 V power source and turn it on using the ON/OFF switch.
2. Raise the equipment gate and ensure the work plate is free of debris. Place approximately 5 g of whole white rice grains evenly on the work plate, avoiding overlapping grains. Lower the gate until it is secured on the piston.
3. On the computer, open the VIBE Analyze software and verify that the format is set for medium to extra-long grains. Adjust the settings according to the grain type in the 'Select Calibration File' option, if needed.

4. Enter the sample code in the 'Sample Name' field, click 'NEW' to capture the image, and optionally enter any comments in the 'Comments' field. Click 'Analyze' to process the image, as illustrated in Figure 10.

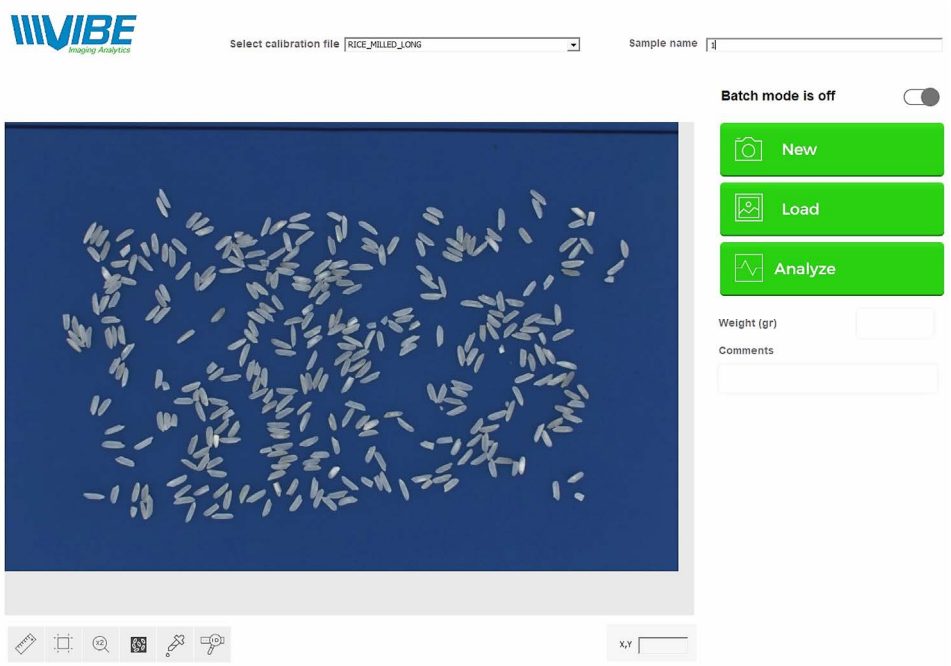

Figure 10. Software interface for sample analysis.

5. When the analysis is complete, click 'CLEAR' to reset the system for the next sample (Figure 11). Repeat the procedure from step 3 with each subsequent sample.

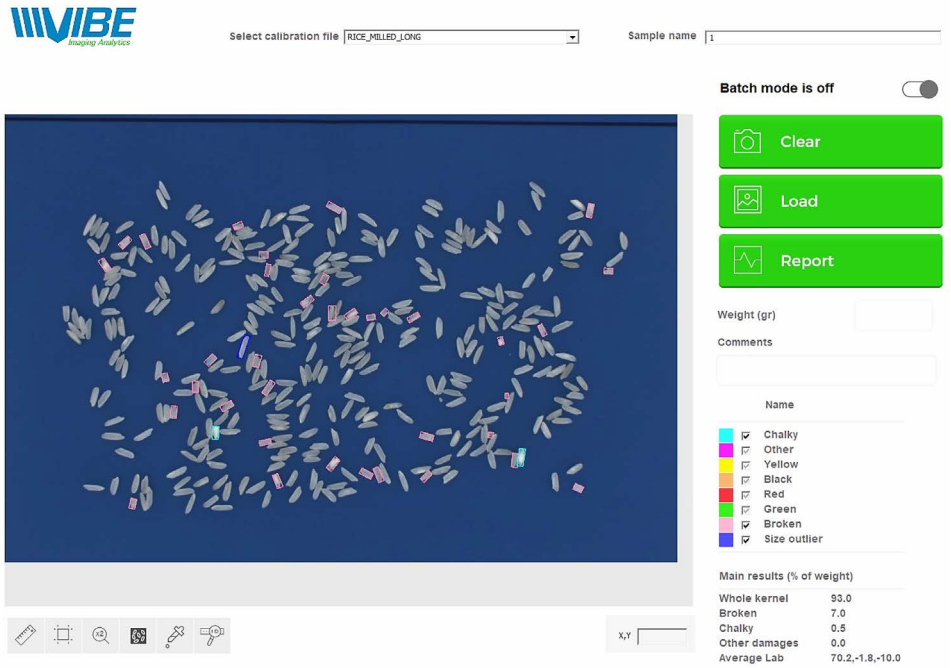

Figure 11. Software interface after completing sample analysis.

4.4.2 Data export

From the computer desktop, click the 'DailyReports' icon. Open the file corresponding to the analysis date and save it in the destination folder in Microsoft Excel 2007–2013 XML (.xls) format.

4.4.3 Quantification of Length and White Core Data

Open the exported Vibe QM3i file. Sample names and comments are located in the 'Sample Name' and 'Sample Comments' columns, respectively. Grain length results are found in the following columns: 'WK_Length_Average' (average grain length), 'WK_Width_Average' (average grain width), and 'WK_LW_Average' (average length-to-width ratio). White core data are located in the following columns: 'Total_Chalky_Percentage' (percentage of white-core grains) and 'Total_Chalky_Count_Percentage' (percentage of white-core grains counted).

4.5. General Procedure for Operating the MachVision Image Analyzer

The following provides a general overview of the steps for capturing, processing, and quantifying rice grain images using the MachVision Rice Analyzer.

4.5.1 Steps for Image Processing

1. Connect the equipment to a 120 V power source and turn it on using the ON/OFF switch.
2. Open the MachVision software and select 'Cargar Configuración' (Load Configuration) according to the grain length to be analyzed (e.g., short grains or medium to extra-long grains) (Figure 12). Place approximately 5 g of whole white rice grains in the input hopper, then press 'Enter' or click 'Procesar' (Process) to start scanning.

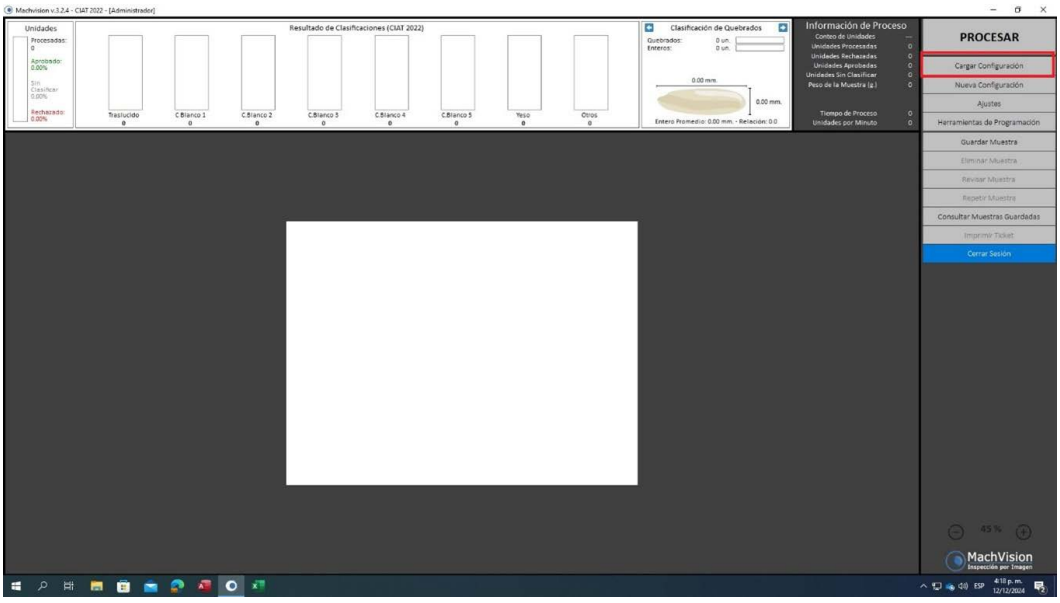

Figure 12. MachVision software interface.

3. Once scanning is complete, click 'Guardar Muestra' (Save Sample) and enter the sample ID, customer name, and project name (Figure 13).

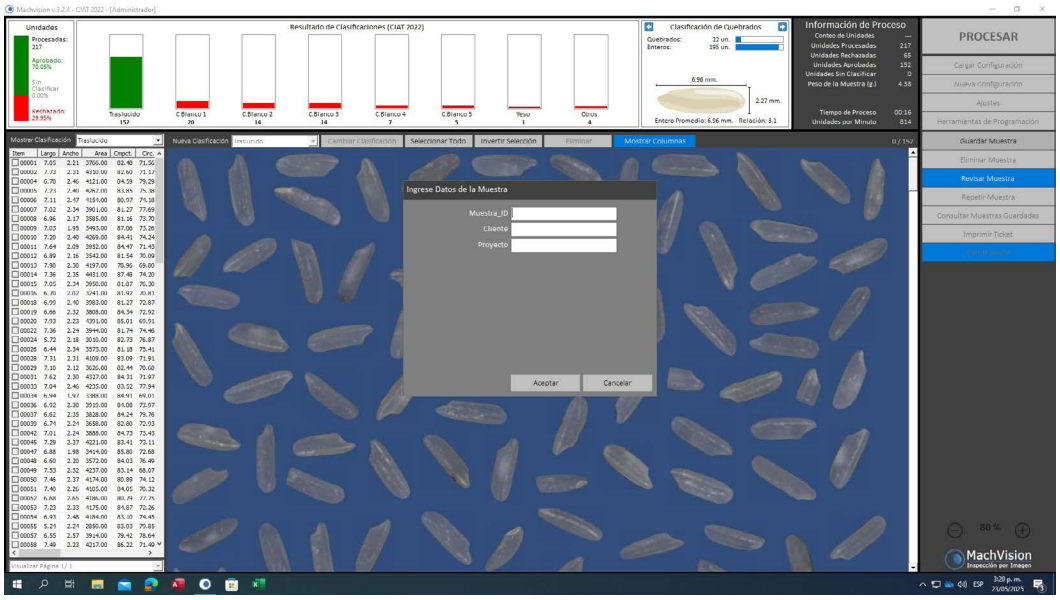

Figure 13. Interface for saving sample data.

4. Before analyzing a new sample, make sure the cells corresponding to white-core grains are empty (Figure 14). Repeat the procedure from step 2 with each additional sample.

   The red box highlights the five white core filters described previously in Figure 5, along with the chalkiness and other grain filters, which correspond to grains without the characteristic white color. The blue box indicates the variables related to grain physical dimensions, specifically length measurements.

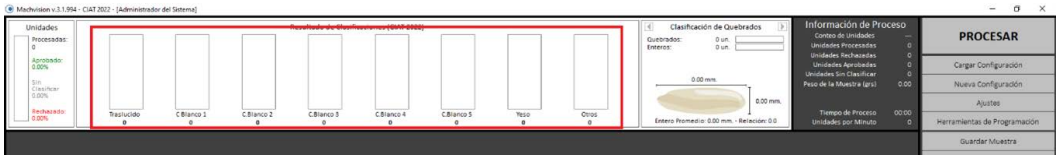

Figure 14. Interface for sample verification.

4.5.2 Data Export

From the desktop, open the 'MVsemillas' database. Apply filters according to the grain type analyzed (short or medium to extra-long), as well as the sample, customer, or project ID. Select the desired data, copy them, and paste them into an Excel spreadsheet. Save the spreadsheet as a backup of the analysis.

4.5.3 Quantification of Length and White Core

In the exported Excel file, use the formula shown in Figure 3 to calculate the white-core value. Extract the columns corresponding to average length, average width, average length/width ratio, and white-core data to serve as the final results of the grain appearance evaluation.

5 Quality Control

To ensure the reliability of the results obtained with the image analyzers, 10% of the samples from each test are validated using a visual reference method for white core evaluation, and a vernier caliper for length measurements. This validation is considered acceptable if the standard deviation between the equipment and the reference method meets the following criteria:

- White core: < 2.0
- Grain length variables: < 0.2 mm

On the other hand, to evaluate the repeatability of image analyzers, the following acceptable deviation limits are established between samples processed under the same conditions:

- Length variables (length, width, length/width ratio): ≤ 0.05 mm
- White core: ≤ 2.0%

If deviations exceed these thresholds, the measurement procedure should be reviewed, the equipment calibration verified, and, if necessary, the analysis repeated to ensure result quality.

6 Waste Disposal and Equipment Cleaning

After completing the analysis, basic cleaning procedures must be carried out to ensure proper equipment operation and to prevent waste accumulation or interference with subsequent readings.

Vibe QM3i analyzer: Raise the gate and check that the work plate is free of rice grains. If necessary, remove any remaining grains with a soft brush or cloth, ensuring that no visible residue remains on the analysis surface.

MachVision equipment: Perform weekly cleaning of the conveyor belt channel. Additionally, if the message "Background/Band" appears at the bottom of the screen, immediately clean the belt with the brush located inside the equipment.

The whole white rice grain used in the analyses is considered organic material without chemical alteration and may therefore be disposed of directly in regular trash without prior treatment.

7 Annexes

This SOP was developed in accordance with the procedures and instructions established in FLAR's Quality Management System, including: The Procedure for the Visual Evaluation of White Core (P-MG008), Measurement of White Core and Length of White Rice through Image Analysis (P-MG041), Grain Classification Instructions (I-MG001), and the Instructions for Instruments and Devices Used for the Proper Handling and Preparation of Samples in the Rice Quality Laboratory (I-MG005).

8 References

Instructivo de clasificación de granos (I-MG001).

Instrumentos y artefactos empleados para el adecuado manejo y preparación de muestras en Laboratorio de Calidad de Arroz (I-MG005).

IRRI (International Rice Research Institute). (1966). Annual Report for 1965. International Rice Research Institute. Manila, Philippines: pp. 79-105.

Martínez C; Cuevas F. (1989). Evaluación de la calidad culinaria y molinera del arroz: guía de estudio para ser usada como complemento de la unidad audiotutorial sobre el mismo tema. Centro Internacional de Agricultura Tropical - CIAT. Tercera Edición. Cali, Colombia.

Medición del centro blanco y la longitud del arroz blanco por medio de análisis de imágenes (P-MG041).

Procedimiento de evaluación de centro blanco visual (P-MG008).

9 Document Revision History

Effective Date of the SOP	Version #	Description	Checked by
June 2025	001	Original SOP	Katerine Loaiza Érika Giraldo Andrea Moná Alexandra Cardona Eduardo Graterol

10 Personal Protective Equipment (PPE)

- Laboratory coat
- Long trousers
- Closed-toe shoes
- Heat-resistant gloves and nitrile gloves
- Safety goggles

11 Notes y Suggestions

The amount of rice required for analysis with the MachVision and Vibe QM3i equipment is 5g. It is essential that the rice grain is whole to ensure accurate measurements. Using a sample that does not meet these characteristics may affect data deviation and repeatability, thereby reducing the reliability of the average results.

MachVision Equipment

- Verify that no grain residues remain in the input hopper before loading a new sample.
- Ensure the correct configuration settings are selected according to grain length.
- Before analyzing a new sample, make sure the cells corresponding to white-core grains are empty to prevent interference with the results.
- Extract and save the processed data according to the selected configuration, applying the appropriate filters for the grain type.

Vibe QM3i Equipment

- Verify that the gate is properly closed before starting image capture to ensure accurate measurements.
- Make sure the work plate is completely flat, free of debris, and that grains do not overlap.

Laboratory Standard Operating Procedure (SOP) **Evaluation of Rice Grain Appearance**	
General Information	
Process Title: Evaluation of Rice Grain Appearance.	
Author: Katerine Loaiza de la Pava	**SOP ID:** FLAR-2025-002
Contact Information: j.k.loaiza@cgiar.org	**Date:** 05/06/2025
Company/Institution: Alianza de Bioversity International y el CIAT	**Version:** 001
This document has been reviewed by:	
Katerine Loaiza de la Pava Érika Fernanda Giraldo Ossa Andrea Fernanda Moná Cortés Alexandra Cardona Libreros	05/06/2025
Final validation by:	
Eduardo José Graterol Matute	

The Latin American Fund for Irrigated Rice (FLAR, its Spanish initials) generates and disseminates knowledge, technologies, and innovations, through partnerships, which contribute to rice competitiveness and sustainability. FLAR brings together various organizations linked to rice from 17 countries in the region, as well and the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) as a strategic partner. https://flar.org/

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. www.cgiar.org

We would like to thank all funders who support this research through their contributions to the CGIAR Trust Fund: www.cgiar.org/funders

To learn more about this iniciative, please visit:
https://www.cgiar.org/cgiar-research-porfolio-2025-2030/breeding-for-tomorrow/

To learn more about this and other iniciatives in the CGIAR Research Portfolio, please visit:
https://www.cgiar.org/cgiar-research-porfolio-2025-2030/

CGIAR BREEDING FOR TOMORROW

Market Intelligence
Area of Work